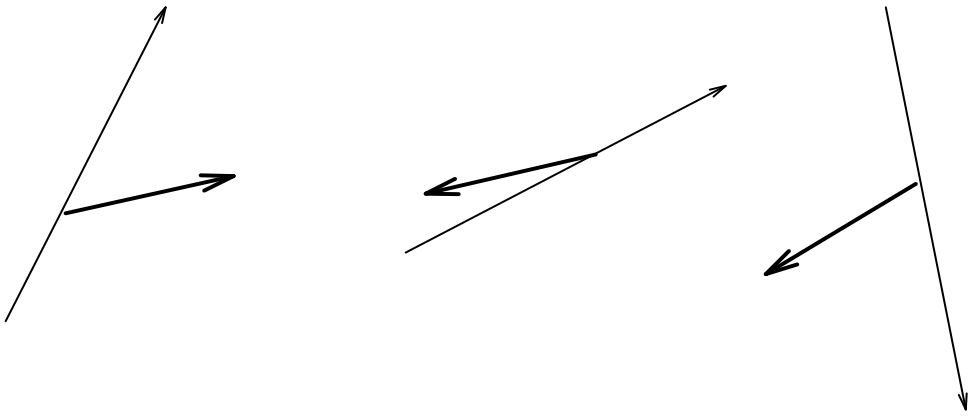
Physics 008: The Quantum World Around Us
Spring 2007
Homework Assignment #1
Due Thursday 1/25/07 **Name:**

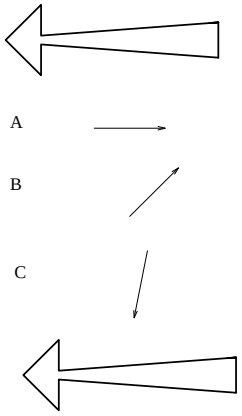
1. (i) In each of the following cases, find the projection of the short thick arrow on the long thin magnetic-field axis. Give your answer in centimeters, with a sign (+ or -).



(ii) What is the maximum possible projection a 2.5 cm arrow can have on *any* axis?

(iii) For a given orientation of the arrow, on how many axes is the projection equal to this maximum value? Explain.

2. Three magnetic needles are placed in the nonuniform magnetic field shown below. Recall that the width of the arrow representing the magnetic field indicates the size of the magnetic field at that location.



(i) What is the direction of increasing magnetic field?

(ii) Describe the projection of each needle on the direction of increasing magnetic field (large, medium, small, positive, negative, etc.).

(iii) What is the direction of the net force on each needle? Explain your reasoning using words and/or diagrams.

3. A Stern-Gerlach experiment is conducted using classical current loops. The experiment is repeated with many loops. Describe the pattern of needles arriving at the screen if
(i) the loops entering the apparatus have random orientations;

(ii) all the loops entering the apparatus have the same orientation;

(iii) the loops entering the apparatus are allowed to have only two possible orientations (corresponding to two different projections).

You should wait until after Tuesday's lecture before attempting the next two problems.

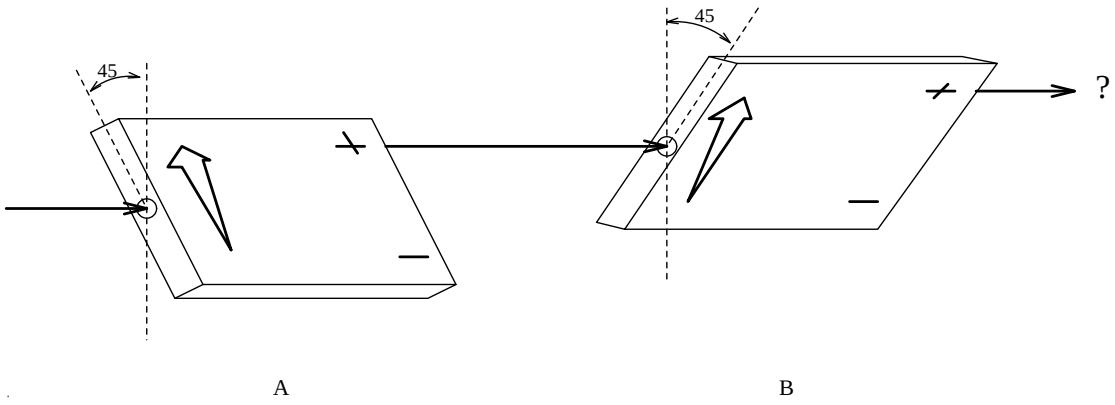
4. In experiment #3 discussed in class, the atoms leaving the - exit of analyzer B were ignored. Describe what would be observed if they were instead fed into

   (i) another horizontal analyzer;

   (ii) a vertical analyzer;

   (iii) an analyzer tilted by an angle θ from the **vertical** axis.

5. Two Stern-Gerlach analyzers are arranged as shown below. Analyzer A is tilted 45° to the left of vertical, and analyzer B is tilted 45° to the right of vertical. Atoms leaving the + exit of A are fed into the input of B.



What is the probability that an atom entering B will leave it through the + exit? Explain your reasoning.

6. *Short Essay:* Consider a **modified** Stern-Gerlach experiment where the beam of classical current loops is shot through a **uniform** magnetic field. Write a short essay (3-5 sentences) describing what pattern you expect to see on a screen at the end of the experiment. Be sure to *explain* the reasoning leading up to your conclusions! *Hint*: To organize your thinking, you may want to consider some of the following ideas: (i) what is the motion of a classical current loop in a uniform magnetic field; (ii) what causes a current loop to deflect in the *original* Stern-Gerlach experiment.